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ABSTRACT

Described is the ninth- through twelfth-grade science program of the Montgomery County Public Schools, Rockville, Maryland. This program provides opportunities for students to experience individual interests and career choices. Two credits in science are taken in grades nine through twelve and generally include laboratory science and biology. Most students elect to take more than one additional science course. The secondary science course electives available to the students include Biology 2, Chemistry 1 and 2, Earth Science, Environmental Science, Horticultural Science, Physical Science 1 and 2, Physics 1 and 2, Laboratory Sciences, Anatomy and Physiology, Applied Science and Aviation Science. Also included is information describing each course and a listing of learning objectives for each course. (DS)

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Program of Studies

SCIENCE
9-12

MONTGOMERY COUNTY PUBLIC SCHOOLS
Rockville, Maryland

SPRING 1979

SE 031 746

PROGRAM OF STUDIES

SCIENCE, GRADES 9-12

Department of Instructional Planning and Development
Montgomery County Public Schools
Rockville, Maryland

Spring 1979

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Rockville, Maryland

FOREWORD

CURRICULUM AND INSTRUCTION

Curriculum may be defined as the general prescription for what teachers should teach and students should learn. In the Montgomery County Public Schools, the *Program of Studies* embodies this prescription. The *Program of Studies* includes the prescribed elements of programs and courses, including course titles, codes, instructional objectives, content descriptions, prerequisites, time allotments, credit values, and a point of view for instruction in each subject area. Based on the MCPS Goals of Education* these prescribed elements constitute the countywide framework within which schools develop and carry out instructional programs tailored to local needs. The relationship of curriculum to instruction in the MCPS, therefore, is that of the more general to the more specific. The *Program of Studies* provides specifications, sets limits, and indicates directions. It has direct and indirect implications for the selection and organization of content, patterns of learning and teaching, and evaluation of outcomes. However, the fulfillment of these specifications and implications is determined at the individual school level. The MCPS instructional program is, therefore, the interaction of the *Program of Studies* framework with the efforts of the individual schools. An appreciation of this interaction is necessary for an understanding of the place of the *Program of Studies* in the work of the schools.

The framework represented by the *Program of Studies* makes possible a unified countywide instructional system which at the same time permits the flexibility of programming required in a large and diverse county. At points, the *Program of Studies* may prescribe instruction very specifically. This may happen with regard to a socially sensitive topic such as sex education, or it may result from the rigorous requirements of establishing an instructional system in mathematics. But this degree of specification is unusual in the *Program of Studies* inasmuch as its level of prescription is generally represented by the instructional objectives it contains for all programs and courses. Instructional objectives are general statements of what the student should attain and are thus appropriate for all students taking a given program or course. Performance objectives are more specific statements of what the student should attain. Formulated or adopted by teachers in relation to the instructional objectives, performance objectives are used in planning classroom instruction. They are thus specific enough to form the basis of day-to-day work and of evaluation of the student's progress. In this movement from instructional to performance objectives, the teacher finds the guidance and the leeway to plan for students of a wide variety of needs and abilities. An examination of the illustrative performance objectives found in instructional guides and in teachers' lesson plans makes clear how great this range is.

An additional means of differentiating instruction which becomes increasingly important at the upper grade levels is provided by elective courses. The use of electives to provide for students of varying abilities and interests differs considerably from subject to subject. Almost all subjects have courses or course sequences which provide for enriched content and advanced or specialized work. Some provide for accelerated movement; some offer additional courses for advanced or specialized work; and some have differentiated paths among required and/or elective courses. The structure of each subject area and the ways by which it employs electives to provide for diverse student needs is indicated in the Grades 9-12 portion of the program description for each subject.

Information regarding each subject area appearing in the *Program of Studies* is presented, when appropriate, as two sections — one for Grades K-8 and one for Grades 9-12. For those subject areas spanning Grades K-12, both sections must be consulted for a full description of the program.

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*Adopted February 12, 1973 by the Board of Education of Montgomery County, Maryland

Each subject area section, whether K-8 or 9-12, has the following subsections: Point of View, General Information, Description of Program, and Instructional Guides.

The Point of View subsection includes reasons for studying the subject, general outcomes sought, ways in which the area of study is pursued in MCPS, and relationships to other subject areas. It also explains how students of varying abilities and interests in the subject are provided with differentiated performance objectives. An explanation of how study of the subject fulfills one or more of the MCPS Goals of Education* is included either in the Point of View subsection or as General Information. For those subject areas spanning Grades K-12, the Point of View is identical in both the K-8 and 9-12 sections.

The General Information subsection includes an explanation of how study of the subject fulfills the MCPS Goals of Education (unless this explanation has appeared in the Point of View) and how it is organized for instruction. Information is given about subject area tests required by the county or state and about federal and state involvement when it is important or distinctive for the subject area. Information about the fulfillment of graduation requirements, Grades 9-12, is also given in some detail for those subjects in which specific requirements exist. Other information specific to the subject also appears.

The largest portion of each subject area section is the Description of Program. It describes the program and supporting courses, identifies the instructional objectives for each, and includes any other prescribed or pertinent elements. For Grades 9-12, this subsection is divided into a List of Courses and a Description of Courses. The List of Courses gives a brief view of subject offerings at this level and serves as a table of contents to the subsection. The course descriptions, along with the narrative material and instructional objectives for each course, give course title, level, length, code, credit value, and prerequisites (if any).

At the end of each subject area section, there appears a list of pertinent MCPS instructional guides. This subsection is amplified to include existing annotated bibliographies, scope and sequence charts, or other such instructional materials in the subject which may have been prepared by MCPS staff.

USE OF THE PROGRAM OF STUDIES

The *Program of Studies*, as the curricular framework for the MCPS, promotes learning through a convergence of educational efforts. Students, teachers, administrators, parents/guardians, and other members of the community use the *Program of Studies* in a variety of ways to achieve the common goal of effective education.

A curriculum stated in terms of general (instructional) objectives informs the *student* of what the school intends him/her to learn and makes it easier to participate in setting specific performance objectives with teachers. Increase in learning efficiency is more apt to take place when a student knows the goal of learning. The student is also more apt to make a commitment to successful learning when at appropriate times he/she is able to select instructional methods and materials. Finally, the student's sense of achievement is reinforced when progress can be noted in the gaining of objectives.

The *teacher* who is familiar with the *Program of Studies* can be more effective in conferring with parents/guardians as well as being in a stronger position to establish specific teaching objectives, plan lessons, select instructional materials, and assess learning progress and teaching functions.

The *school principal* uses the *Program of Studies* as an administrative guide in its listing of approved courses, titles, and codes. The administrator can also deepen staff and community understanding for the

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total educational program as the *Program of Studies* is employed in teacher conferences, faculty and department meetings, and parent/guardian meetings. School effectiveness can be enhanced as the principal organizes people and resources to help learners gain the stated ends of instruction.

Learning outcomes and other information included in the *Program of Studies* give *parents/guardians and other members of the community* information useful to them. They can better understand the instructional program for their elementary school children and advise secondary school youth in course selections. Knowledge of the *Program of Studies* also enables families and other community members to communicate more effectively with their children, teachers, and school administrators.

CURRICULUM CHANGE AND MODIFICATION OF THE PROGRAM OF STUDIES

The curriculum of any public school system must reflect the continual change of the society of which it is a part. As the MCPS curriculum changes, the *Program of Studies,* which establishes the MCPS curriculum in printed form, must be modified accordingly.

In MCPS, a proposal for a new or revised program or course can originate with any individual or group in the community or school system. The staff of the Department of Instructional Planning and Development encourages, coordinates, and assists the development of such proposals. In general, the staff has responsibility for modification of curriculum as required by state and local law and policy, and for continual assessment of the need for curriculum change. Procedures for effecting changes in curriculum and the *Program of Studies* are specified in MCPS Regulation 345-1, "Development and Approval of Curriculum and Supporting Materials." These procedures first state the involvement of community and school personnel in the initiation, development, review, and tryout of proposed curriculum changes; describe the role of the Council on Instruction as a reviewing and recommending body for the superintendent; and identify the final steps of approval by the superintendent and the Board of Education. The regulation also cites relevant portions of these Board of Education policies and Maryland public school laws upon which its procedures rest.

STATE AND FEDERAL GOVERNMENT IN RELATION TO THE CURRICULUM

The major influence of the Maryland State Department of Education upon local curriculum has traditionally been through the MSDE's specification of the requirements for graduation from high school. (These graduation requirements and other provisions for earning credit are summarized on page vii.) Two newer and equally important MSDE influences stem from a state educational accountability law* and the currently evolving Project Basic.**

The Maryland Educational Accountability Act imposes several requirements in its implementation of statewide accountability. These include the establishment of goals and objectives in, but not limited to, reading, writing, and mathematics at three levels — state, school system, and individual school. The goals and objectives at the system level must conform with those established at the state level, and those established by individual schools must conform with those of the local system and the state.

Also required by the Act is a school-by-school survey of the current status of student achievement in relation to established objectives, the development of programs by each school for meeting its own needs, and the establishment of evaluation procedures for determining the effectiveness of these programs. Regular reevaluation of programs, goals, and objectives is also a stipulation of the Act.

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*Article 77, Section 28a, of the *Annotated Code of the Laws of Maryland* was passed during the 1972 session of the Maryland General Assembly. The law has come to be called the "Educational Accountability Act."

**See "The Comprehensive Plan Maryland Competency-Based Prerequisites for Graduation," a publication of the Project Basic Office of the Maryland State Department of Education, 1978.

The state plan for implementation of the Accountability Act* specified that, effective the spring of 1974, the Iowa Test of Basic Skills and the Cognitive Abilities Test would be given to all pupils in Grades 3, 5, and 7. Use of these tests has given rise to concerns about the limitations of nationally norm-referenced tests and the small part of the MCPS curriculum that is measured by the ITBS. As a result, the Maryland State Board of Education has adopted a new schedule of assessment which includes the use of the Maryland Functional Reading Test and the Maryland Functional Mathematics Test in the secondary grades. These two tests, developed at the state level, are criterion-referenced tests. This means that they test specific skills or information without regard to how well similar student populations do on a given test item. Students who pass these tests in the ninth grade will not be tested again in connection with this program. Those who fail either test will receive appropriate instruction and retesting.

Through its Project Basic, the Maryland State Board of Education is reaffirming its responsibility for establishing statewide educational standards and stating its commitment to the development of behaviors basic to effective adulthood.** The state board specified five areas of human activity in which students should develop skills and attitudes for life-functioning. The five areas and their definitions as stated in the paper are:

A. Basic Skills — All people must be able to read, write, and calculate.

B. Survival Skills — Schooling should equip all public school youth with these kinds of fundamental skills: consumer, parenting, interpersonal relations, mechanical, and personal finance.

C. World of Work — Schooling should lead to securing employment upon graduation or post-secondary education. All public school youth should be made aware of the options and opportunities of the world of work without racial or sexual bias.

D. World of Leisure — Schooling should help the student become involved in creative and healthful lifetime activities.

E. Citizenship — Citizenship should include becoming involved in the electoral process, participating in local civic affairs, and understanding the system of justice.

To implement this action of the Maryland State Board of Education, State Superintendent of Schools David Hornbeck established the Project Basic Office. Its staff is currently involved in identifying the basic competencies in the five areas. It is also to design and develop instructional activities for the five areas of human activity, develop assessment measures to certify student acquisition of the specified competencies, and coordinate the statewide implementation of minimal competencies as a prerequisite to graduation. The project is to be fully implemented by 1982.

The impact upon the MCPS curriculum of the educational accountability and the competencies programs is as yet difficult to calculate. In one sense, the impact may not be great because the objectives of the accountability program (and, it is anticipated, the competencies of Project Basic) are to a large extent already included in the MCPS curriculum. References to the impact of the educational accountability law on specific portions of curriculum are included in the *Program of Studies* within the Information sections of the descriptions for Reading, English Language Arts, and Mathematics. On the other hand, these two state programs may have a significant impact on curriculum emphasis and

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*See the "Maryland Handbook on the Accountability Assessment Program, Maryland State Department of Education, Adapted to MCPS Test Administration Procedures," issued by the MCPS Department of Pupil and Program Appraisal, February 1, 1974.

**See *The Mission of Schooling*, Maryland State Board of Education, January 1977.

balance. They could affect time allotments within and among subjects and courses and thus affect even the definition of the subjects and courses themselves. How these statewide programs are developed and how MCPS students perform on the required evaluations will determine the impact of these programs upon curriculum. They are certain to have impact upon instruction and probably even more impact on evaluation procedures.

Federal and other state involvement in curriculum is mentioned in the descriptions of those subject areas where it is found, e.g., health education and some of the vocational education subjects.

TIME ALLOCATIONS AND GRADUATION REQUIREMENTS

In the following chart, time allocations are shown for subjects Kindergarten through Grade 8. The allocations are given in minutes per week, and school administrators are expected to use them in establishing program balance.

Subject	K	Grades 1-2	Grades 3-6	Grades 7-8
English Language Arts/Reading	200	700	475	225
Mathematics	75	200	225	225
Music	100	100	100	75
Physical Education	125	150	150	225
Science	75	125	225	225
Social Studies	75	125	225	225
Home Economics and Industrial Education	—	—	—	75
Electives				225
Total	750	1500	1500	1575

The MCPS Policy on the Middle School directs the school system to provide "a curriculum based on the developmental needs of pre- and early adolescents which places primary emphasis on acquisition of basic skills but also provides a wide range of exploratory and enrichment experiences."* Middle schools are organized into interdisciplinary teaching teams which provide opportunities for flexible student grouping and scheduling. Therefore, daily, weekly, and master schedules in middle schools will not be characterized by fixed time intervals for each subject area.

New standards for high school graduation were enacted by the Maryland State Board of Education on November 27, 1974, and became effective for students entering ninth grade in the fall of 1975. These standards thus become effective for all students in Grades 9-12 in the school year 1978-79. The standards define a unit of credit; specify credit requirements for graduation; and list several provisions for earning credit and several alternatives to four-year enrollment. MCPS Regulation 310-3, "High School Graduation Requirements," includes these state graduation requirements, the policy of the Montgomery County Board of Education with regard to them, and guidelines for their implementation.

*The MCPS Policy on the Middle School, adopted December 13, 1977

With exceptions specified under "Alternatives to Four-Year Enrollment," the MCPS student must, beyond the eighth grade, complete four years of approved study and earn a minimum of 20 credits. Twelve and one-half of these credits must be in the areas specified below. The additional seven and one-half elective minimum units may be chosen from offerings in any curricular area.

English Language Arts	4 credits
Social Studies	3 credits (One must be United States History; and one must deal with contemporary issues including local, state, and national governments.)
Science	2 credits
Mathematics	2 credits
Physical Education	One-half credit, required in Grade 9, and one-half credit sometime during Grades 10-12
Physical Activity*	Two semesters of physical activity sometime during Grades 10-12 (One-half credit of elective physical education fulfills the requirement of two semesters of physical activity.)
Health Education	One-half credit, required in Grade 9

The several provisions listed by the state for earning credit in addition to regular school day and school year programs are summer school, evening school, correspondence courses, tutoring, examination, and work study programs or experience outside the school. On pages 10 and 11 of MCPS Regulation 310-3, the Montgomery County Board of Education guidelines for each of these provisions are shown. The provision on credit by examination is being implemented as examinations appropriate to MCPS courses can be developed. During the 1977-78 school year, such examinations were given for Algebra 2; Trigonometry; and English, Grade 12.

The alternatives to four-year enrollment are an accelerated twenty-credit program; an early college admission program; early admission to approved vocational, technical, or other post-secondary school; and a job entry training program. To receive a high school diploma through any one of these alternatives, the MCPS student must receive approval for waiver of the four-year enrollment requirement. MCPS Regulation 310-3 includes the steps for requesting and receiving approval of the waiver. In addition to reading the regulation, which is available in all school offices and in school instructional materials centers, students and parents/guardians should consult local school counselors with regard to any of these provisions or those concerning earning credit outside the regular school day and year.

INTERAGENCY PROGRAMS

As has been stated, the *Program of Studies* prescribes the curriculum for all MCPS students by allowing for much differentiation of instruction. Instructional alternatives are created by varying content, assessment criteria, pace, and the pattern of courses the student takes. Beyond this differentiation, special instruction and other services are provided for handicapped students. In order to provide programs for all handicapped students, MCPS coordinates services with local and state agencies and other resources.

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* See pages 3-4 of the Physical Education Grades 9-12 section of the *Program of Studies*.

For those students who are most severely handicapped, including those who are placed outside of MCPS schools, the MCPS curriculum is adapted as required to meet the limitations of the students. Information about programs for these students is available from the Placement Unit of the Department of Interagency Programs, MCPS Office of Continuum Education.

AVAILABILITY OF INSTRUCTIONAL MATERIALS

The instructional guides listed at the end of each subject area section of the *Program of Studies* are on file in school Instructional Media Centers and in the Professional Library (formerly the Educational Materials Laboratory) at the Educational Services Center. They may be ordered from the Division of Supply Management, Department of School Services, MCPS Office of Supportive Services, which maintains a list of the guides stocked in its warehouse.

Occasionally, there will be a need in a subject area for publication of some supplemental instructional material such as a scope and sequence chart or a bibliography. If such exist, they are also listed at the end of the subject area section.

The Department of Instructional Resources, MCPS Office of Program Development, maintains files of approved textbooks and text materials and of approved films. A list of approved textbooks and text materials is published annually. Questions regarding this list should be addressed to the Division of Instructional Materials, Evaluation and Selection. A list of approved films is published periodically, and questions regarding it should be addressed to the Film Library of the Division of Instructional Materials, MCPS Department of Instructional Resources.

The Goals of Education

Adopted by the Board of Education — February 12, 1973

The goals of education for the Montgomery County Public Schools are set forth in this statement of public policy to guide the school system in developing, implementing, and improving educational programs for its students. This statement outlines those goals considered by the citizens of the county as most important for the education of their children in public schools and for which the citizens will hold the school system responsible and accountable.

The school system has the primary responsibility for some of these goals. For others, it shares that responsibility with the home and other community institutions.

The extent to which these goals can be realized will depend upon the endorsement by and continuing commitment of the school system staff, students, parents, and the community. With broad endorsement and wide support, the Montgomery County Public Schools will continue its development to serve its students and community in the most effective way possible.

Education is a process that encompasses the total experiences of each individual throughout a lifetime of formal and informal learning. The school program, as a keystone in this process, should provide opportunities and encouragement for students to acquire knowledge, to explore ideas, to ask questions, and to seek answers that will lead to sound and useful conclusions.

The probability of success motivates students to learn. Each school must create a program and maintain a climate in which every student has opportunities for success. Each individual is unique, and the school shall encourage that uniqueness. The school should help the student understand his [/her] values and the values of others.

The school program, while developing the skills of learning, should be based on the study of broad human concerns, flexible enough to deal with changing concerns and at the same time related to the needs, interests, and concerns of each student. The program should offer opportunities for decision-making. It should help the student develop the capacity to learn throughout his [/her] lifetime, to respond to and understand other human beings, and to accept full responsibility for the results of his [/her] actions.

Therefore, the Montgomery County Public Schools dedicates itself to provide the opportunity, encouragement, and guidance to make it possible for every child to attain the following goals of education:

ACADEMIC SKILLS

The fundamental responsibility of the school is to develop programs that enable each child to acquire those skills basic to all learning. The achievement of all other goals depends upon the success of the school in ensuring that each student, according to his [/her] own abilities, attain the following basic skills:

- **Reading:** The ability to read and comprehend written material and relate it to other knowledge
- **Composition:** The ability to write with precision, clarity, and acceptable usage, whether to inform, inspire, or persuade
- **Listening and Speaking:** The ability to listen attentively and with understanding and to speak with confidence and effectiveness, whether from written material or extemporaneously
- **Mathematics:** The ability to perform computations, to solve common problems of mathematics and logic, and to understand the structure of mathematics so it can be a useful tool in daily living
- **Study:** The development of basic study skills so that he [/she] may acquire knowledge efficiently
- **The Arts:** The development of some of the basic disciplines and skills in the performing and creative arts to be used throughout his [/her] life for communication, expression, and enjoyment
- **Observation:** The ability to identify and differentiate elements of the world around him [/her] as they are useful in personal, academic, and artistic pursuits

PHYSICAL DEVELOPMENT

Each person matures physically at a different rate and possesses differing capabilities. The school has the obligation to help each student:

- understand the biological functioning of his [/her] body
- make the best both of physical talents and limitations
- develop good health habits, skills, and interests to maintain his [/her] body in optimum condition throughout his [/her] lifetime

INTELLECTUAL DEVELOPMENT

In addition to acquiring academic skills, each individual should develop his [/her] intellectual capabilities to the fullest extent possible. Therefore, the school will encourage each pupil:

- to think creatively
- to reason logically
- to apply knowledge usefully
- to deal with abstract concepts
- to solve problems

THE INDIVIDUAL AND SOCIETY

Every person must learn to live in a society. The school must help each student develop an understanding of [people] and of how the individual depends upon others and they on him [/her]. This requires that each student gain:

- knowledge of himself [/herself] and the characteristics, needs, and desires he [/she] shares with others
- sensitivity to others and their ideas, and the ability to act responsibly in various situations
- the ability to function productively as a member of a group
- familiarity with the legal, moral, ethical, and cultural heritages of his [/her] and other societies
- knowledge of the various political systems and philosophies of the world

SCIENTIFIC UNDERSTANDING

[We] must exist in the natural world. The school must help each student understand nature's impact on [us] and [our] impact on nature. This requires that each student gain:

- knowledge of natural phenomena and their effect on [people]
- understanding of scientific advances and their part in modern technology
- understanding of the scientific method
- appreciation of the ways in which the application of scientific principles can improve the quality of life while preserving the natural order

AESTHETIC EXPRESSION

[We], to realize [our] full potential, must be able to sense and appreciate beauty in the world around [us], whether created by nature or by [people]. The school must help each student gain:

- knowledge of the nature of the creative performing arts
- experience with a wide variety of art forms
- a perspective for developing his [/her] own aesthetic criteria and tastes
- understanding of the contribution of the arts to human communication

CAREER DEVELOPMENT

Productive and satisfying work enriches [our lives]; and with increasing leisure time, many people will use various occupational skills for avocational purposes as well. The school must help each student gain:

- knowledge and appreciation of the wide variety and interrelationships of occupations in modern society
- opportunities to explore potential occupations in relation to personal aptitudes and interests, unrestricted by stereotypes of sex, race, or socio-economic level
- the knowledge, skills, and abilities that enable him [/her] to secure satisfying employment, embark upon further training and education in a chosen career field, and adapt occupational talents to changing job demands and opportunities

COMMITMENTS

The Board of Education and the staff of the Montgomery County Public Schools must create and maintain an educational environment that promotes the attainment of these goals by all students. Toward this end, therefore, the public schools make the following commitments to the citizens of Montgomery County:

- *To attract and retain the most qualified and best trained staff possible through dynamic programs of recruitment, supervision, and continuing in-service training and staff development opportunities*
- *To develop and implement a comprehensive and flexible instructional program to achieve the aforementioned goals and to provide the facilities, materials, and equipment needed to enhance the effectiveness of the program*
- *To evaluate the effectiveness of the instructional program continuously, and regularly report the findings to students, parents, staff, and the community*
- *To adopt new and different approaches when it is determined that they will contribute more effectively to the fulfillment of the goals*
- *To encourage a continuing dialogue with the entire community, making every effort to communicate needs and achievements, and to be responsive to the needs and aspirations of the school community*
- *To utilize facilities and staff, in cooperation with other agencies, in the development of preschool, community school, and adult education programs that will meet the continuing educational needs of all citizens*
- *To provide an accountability procedure for informing county citizens of the objectives and costs of their school system and of reporting periodically on the educational investments made with their tax dollars*

SCIENCE, GRADES 9-12

POINT OF VIEW

The Montgomery County Public Schools has as one of its Goals of Education* that each school provide the opportunity, encouragement, and guidance for each student to attain scientific understanding. The goal is stated in terms of scientific understanding:

> [People] must exist in the natural world. The school must help each student understand nature's impact on [people and their] impact on nature. This requires that each student gain:
>
> - knowledge of natural phenomena and their effect on [people]
> - understanding of scientific advances and their part in modern technology
> - understanding of the scientific method
> - appreciation of the ways in which the application of scientific principles can improve the quality of life while preserving the natural order

The MCPS science program supports this commitment.

Science concerns a human enterprise which seeks to organize a system of general laws to account for the phenomena observed in the physical or material world. Much of the character of science is contained in the ways in which apparently factual or hypothetical evidence is sought and brought to bear on these organizational problems. The special nature of science is exemplified by attempts through observation, experiment, and analysis to reduce to a minimum number of consistent generalizations society's increasing understanding of natural phenomena.

The inventory of scientific information currently being discovered and cataloged is making it difficult for science specialists to know all that is being done in their own narrowing fields of study. It is impossible to know what content being taught today will be of most use to our present school population in future years; but it is clear that scientific literacy will continue to be extremely important to our young people, now and as they grow older. Science can flourish best in a cultural and social environment in which the nature of the scientific enterprise is reasonably well understood.

Understanding of the substantive elements of science may be developed in three broad categories:

1. **The data of science:** the body of recorded facts, concepts, principles, and generalizations which permit an orderly description of what informed people believe to be true of the natural world. The data of science may be organized into a number of arbitrary divisions for study and reference, the number and character of the divisions depending upon the needs and purposes of the organizers. For the purposes of general education K-12, it is convenient to arrange this material into the following conventional and simplified divisions: (a) matter; (b) energy; (c) physical interaction; (d) living things; (e) biological interdependencies; and (f) the changing universe.

2. **The processes of science:** the set of typical assumptions and practices which people have used to discover, assess, synthesize, predict, and catalog the data of science. These processes require perceptions and skills in operating with such items as the nature of evidence and hypothesis; probability and prediction; observation, experiment, and conclusion; measurement, error, and control; test, rejection, and modification; definition and delimitation; and accuracy in language. It is convenient to arrange these elements as (a) identifying and analyzing problems; (b) designing and conducting experimental procedures for the solution of problems; (c) interpreting results of experiments; (d) projecting and predicting next steps; and (e) reporting and organizing results.

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3. **The applications of science:** all the ways by which the data and processes of science have been utilized by people and societies to influence their relationships with the natural world and with each other. Science has been instrumental in the (a) modification of living standards and economic development; (b) improvement of personal and community health; (c) establishment of cultural values; (d) adjustment of social and political problems; and (e) exploitation, conservation, and restoration of the environment.

A program for general education in science must include opportunity for selected experiences with all of the above. The balance and emphasis accorded to each should vary in respect to the apparent requirements of individual learners and in general with the experience and maturity of all students. In recent years, many professional scientists and science educators have recommended increasing emphasis of the *processs* of science while decreasing stated emphasis on the *data* of science and very often omitting almost all reference to the *utility* of science. This intellectual bias favoring "pure science" has resulted in the development of a series of courses which are satisfying to many students but which are rejected by others as not being relevant to contemporary societal problems. "Science" is often alleged, improperly, to be responsible for many of the conditions which disturb individuals and societies at this time. Such misunderstanding and lack of objectivity, while not universal, indicates that science education in the past has not been entirely effective. More recently, science program designs and classroom activities have included more emphasis on the applications of science, particularly as they affect the relationships among science, technology, and society.

For these reasons, the following general objectives for the K-12 science program are considered to be necessary for the general education of students and for the development of a scientifically literate society. The science program should provide for:

Understanding of systematically selected scientific concepts, principles, and generalizations and competence in applying those which are important to the realization of personal goals and to intellectual, technological, and social advancement

Experiences with numerous activities designed to develop appreciation for the skills in logical, critical, and creative thinking, particularly through familiarity with the processes of science

Experiences in an atmosphere of integrity in science activities which encourage and allow students to react to and interpret stimuli with objectivity

Experiences in science activities which allow students to develop creative and emotionally satisfying feelings regarding themselves, their society, and their environment

Experiences throughout the science program which enable students to assess their interests and abilities for the pursuit of a career in science or technology

Differentiated performance objectives to meet the needs of students of varying ability levels and interests

Interfaces with other subject areas and programs including environmental, outdoor, and consumer education; drug abuse; health science; basic skills of reading, writing, and mathematics; and career education

GENERAL INFORMATION

High school graduation requirements include a minimum of two credits in science taken in Grades 9 through 12. For students who complete their study of science with Laboratory Science and Biology 1, Laboratory Science is often their culminating secondary school instruction in the physical sciences. Most students, however, elect more than one additional science course.

In nearly all circumstances, the teachers' guides written for the particular textbooks adopted by MCPS will be very helpful to teachers and are approved for use concurrently with the textbooks. High school science teachers are also expected to exercise their individual professional judgments in selecting course materials and in planning classroom activities and teaching schemes within the freedoms and restraints which have been noted for science teachers in earlier grades. This includes differentiating performance objectives and lesson activities to meet the varying abilities and interests needs of students.

At the high school level, there are a number of opportunities for students to experience individual interests and career choices. An internship program for science laboratory or field research outside the school can be arranged if a suitable site for the work is available. Advanced and special interest elective courses are offered in most schools. There are also courses for students whose major interests lie outside the field of science in such areas as cosmetology and industrial education. Throughout the school year, there are announcements of special seminars, programs, and competitions for interested students.

The secondary science program contains courses and topics within courses that relate to science and technical writing and reading, mathematical applications, environmental issues, and consumer and technology education.

There are lessons and topics in various courses to support the general career education student outcomes indicated below. Classroom activities and instructional materials will help the student to:

- analyze the skills required for certain jobs
- determine that within each of the occupational clusters there is a wide range of occupations
- determine the characteristics of various jobs and/or careers in career clusters of interests
- analyze careers by participation in a real or simulated exploration activity
- analyze the relevancy of learning an academic or vocational skill and the application of that skill on the job
- outline a tentative educational plan by selecting appropriate academic and vocational courses
- examine entry level criteria for specific jobs in occupational clusters of interest
- develop positive work attitudes for career success
- develop human relations skills which affect job performance

DESCRIPTION OF PROGRAM

List of Courses*

Laboratory Science

Anatomy and Physiology

Applied Science

Aviation Science

*All courses listed can be offered as two semester-courses.

Biology 1
Biology 2
Biology, Advanced Placement

Chemistry 1
Chemistry 2
Chemistry, Advanced Placement

Earth Science

Environmental Science

Horticultural Science

Physical Science 1
Physical Science 2

Physics 1
Physics 2

Internship — Science

Description of Courses

Laboratory Science — Grades 9, 10, 11, 12
3592 1 year 1 credit

Laboratory Science is a laboratory-oriented, equipment-based course which emphasizes observation, experimentation, and analysis to develop skills, understandings, and attitudes applicable to succeeding laboratory courses in high school science. Specific skills for working with instruments and materials and a knowledge of selected scientific principles and processes are developed. The plan of the course is not identical with that of any existing textbook or laboratory manual; consequently, materials from a variety of sources must be selected. The course can be taught in two semesters. The course consists of five units. Laboratory Science A includes Physical Measurement; and Force, Motion, and Simple Machines. Laboratory Science B includes Basic Inorganic Chemistry; Basic Organic Chemistry; and Environmental Studies. Laboratory Science A is a prerequisite for Laboratory Science B.

Laboratory Science A — Grades 9, 10, 11, 12
3591 1 semester ½ credit

Topics are historic development of measurement; metric conversions; linear measurement; liquid volume measurements; mass measurement; interpolation and extrapolation of points; significant figures; rounding and powers of ten; area of regular and irregular surfaces; volume of regular and irregular shaped objects; temperature scale conversions; water displacement; density of solids; density of liquids; Archimedes Principle; specific gravity; heat loss versus heat gained; effect of heat; specific heat; time and its measurement; history of time and motion; work and simple machines; motion-velocity, and acceleration and momentum.

Upon completion of Laboratory Science A, the student should be able to:

- develop practical skills in scientific computation and measurement in the metric system
- process physical measurement data collected by experimental methods
- develop skills in the use of laboratory instruments for physical measurement
- develop a concept of time and a means for expressing time intervals

- recognize that concepts of time and motion have evolved as a result of the efforts of scientists' attempting to describe natural phenomena
- perform experiments, record data, and prepare graphs in the study of motion to include time, distance, velocity, acceleration, and momentum

Laboratory Science B — Grades 9, 10, 11, 12
Prerequisite: Attainment of the objectives of Laboratory Science A
3592 1 semester ½ credit

Topics are care and use of equipment; history of atomic theory; atomic structure; properties of metals and nonmetals; periodic table; physical changes; solutions, suspensions, emulsions; chemical changes; chemical formulas; chemical equations; acids, bases, and salts; metals; properties of carbon; hydrocarbons; alcohols; organic acids; esters; other organic groups; products of petroleum and coal; environmental issues and problems; solid waste; population densities; air and noise pollution; water pollution; and energy utilization.

Upon completion of Laboratory Science B, the student should be able to:

- determine the mechanical advantage and efficiency of simple machines
- develop skills in the use of chemical laboratory equipment
- understand the atom as the basic unit of matter
- understand the organization of the elements
- know the differences between physical and chemical changes
- recognize classes of chemical compounds
- know the nature of carbon and its compounds
- understand the relationships among members of homologous series of organic compounds and their naming systems
- know the structures, formulas, and properties of the common organic functional groups
- know the processes used in producing petroleum and coal products for fuels
- know general environmental issues and problems
- learn environmental factors which control population densities
- use investigative techniques to study air and noise pollution
- use investigative techniques to study water pollution
- understand the relationship between energy utilization and the environment

Anatomy and Physiology — Grades 10, 11, 12
3763 1 year 1 credit

A prerequisite for Anatomy and Physiology is attainment of the objectives of Biology 1 and, where the student has not attained the objectives of Chemistry 1 and will not be taking it concurrently, counseling based on 1) recommendations of teachers who have taught the student and 2) performance in previously taken science courses. The course includes a study of structures and functions of the major systems of the human body. When applicable, comparative anatomy and physiology of other mammals are studied. The course is designed for the advanced student who has demonstrated achievement in biology and is interested in pursuing a more rigorous study of physiological systems.

The course can be offered on a semester basis. Anatomy and Physiology A topics include cell specialization; skeletal system; muscular system; nervous system; sense organs; and digestive system. Anatomy and Physiology B topics include respiratory system; circulatory system; endocrine system; integumentary system; excretory system; reproductive system; heredity; and genetics. The sequencing of topics within a semester is flexible. Anatomy and Physiology A is a prerequisite for Anatomy and Physiology B.

Anatomy and Physiology A — Grades 10, 11, 12
3761 1 semester ½ credit

Upon completion of Anatomy and Physiology A, the student should be able to:

- describe the historical development of the study of human anatomy and physiology
- demonstrate the planes of reference of the human body
- describe the structure of atoms and molecules and their variation as they apply to the chemistry of human systems
- distinguish among types of human cells, tissues, organs, and organ systems
- describe the structure and function of the human skeletal system
- describe the structure and function of the human muscular system
- describe the structure and physiology of the human nervous system
- describe the structure and function of human sensory organs
- compare the chemistry and function of carbohydrates, lipids, and proteins
- demonstrate the body's ability to use enzymes and vitamins
- describe the structure and function of the human digestive system

Anatomy and Physiology B — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Anatomy and Physiology A
3762 1 semester ½ credit

Upon completion of Anatomy and Physiology B, the student should be able to:

- describe the structure and function of the human respiratory system
- describe the structure and function of the human circulatory system
- describe the structure and function of the integumentary system
- explain how the human body maintains homeostases of temperature and water
- describe the chemical balances that control the physiology of human beings
- describe the structure and function of the endocrine system
- describe the structure and function of the human reproductive system
- describe embryonic development of human systems
- apply Mendelian laws to human genetics
- apply molecular genetic principles to human genetics
- describe the causes and cures of dysfunction of the human organism
- describe career opportunities in medically related fields

Applied Science — Grades 10, 11, 12
3612 1 year 1 credit

This general course provides students an opportunity to study and investigate a wide range of practical applications of biological and physical science concepts and processes. Topics of study may vary according to students' needs and interests. All topics will relate to the application of science and technology for personal health and comfort, vocational careers, or consumer products. Typical topics are the science of household appliances and engines, the effects of nutritional and other health practices on human anatomy and physiology, and the exploration of a science topic of personal interest or a science-related career or vocation. Students are encouraged to select and do independent study on science or science-related topics of interest to them. The course may be taught in two semesters with topics of physical science in Applied Science A and topics of biological science in Applied Science B. Either semester can precede the other.

Applied Science A — Grades 10, 11, 12
3611 1 semester ½ credit

Upon completion of Applied Science A, the student should be able to:

- explain the basic scientific principles involved in the operation of common household mechanical appliances and private transportation conveyances
- investigate the scientific principles of household electricity and electrical appliances
- select an area of science in which to do some library or laboratory research and present the topic in oral, written, or visual form

Applied Science B — Grades 10, 11, 12
3612 ½ credit

Upon completion of Applied Science B, the student should be able to:

- describe expected changes in human anatomy and physiology that result from various health practices
- explain underlying scientific principles utilized in common household and personal activities such as gardening, dieting, exercising; and special studies such as cosmetology
- explore a science or science-related career or vocation

Aviation Science — Grades 10, 11, 12
3863 1 year 1 credit

Aviation Science is designed primarily for secondary students who have a definite interest in the aeronautical aspect of aerospace activities. It is intended to develop in the student a basic understanding of the scientific and technological fundamentals involved in flight. The earth, physical, and biological sciences are taught as they relate to the aerospace age. The course encompasses the equivalence of a Federal Aviation Agency-approved private/commercial pilot ground school curriculum and should prepare the student to take the FAA written examination for private pilot's license. The FAA examination is given at the student's option, upon completion of the course. The course does not include flights or flying experience with aircraft.

Aviation Science can be taught in two semesters. The units included in Aviation Science A are Aviation History; The Air and Space Age; Careers in Aviation/Aerospace; Science of Flight; Airplane Systems and Instruments; Weight, Balance, and Performance; and Meteorology.

Aviation Science B includes Basic Navigation; Radio Navigation; Air Traffic Control and Communications; Airman's Information Manual; Federal Aviation Agency Regulations; Physiology of Flight; The Nature of Space; and Rocket Fundamentals. Aviation Science A is a prerequisite for Aviation Science B.

Aviation Science A — Grades 10, 11, 12
3861 1 semester ½ credit

Upon completion of Aviation Science A, the student should be able to:

- demonstrate scientific principles of the reaction between air and a moving wing, Newton's Laws, and Bernoulli's Principle
- demonstrate concepts of the four forces which act upon an airplane in flight
- demonstrate controlled movement and stability design of an aircraft

- investigate stresses imposed in flight
- demonstrate concepts of the three axes of aircraft movement
- understand basic mechanics of reciprocating engines
- demonstrate functions of carburetor, heat, brake, and landing gear systems
- understand ignition system components, purposes, and preflight inspection
- read tachometers and pressure gauges
- explain functions of flight instruments
- understand gyro-instruments
- demonstrate a model of weight, gross weight, and balance relationships
- compute with graphs various problems of weight and balance
- compute sample problems of aircraft load for weight and balance control
- explain functions and symbols of the National Weather Service
- explain formation of various weather phenomena such as clouds, turbulence, and fronts
- discuss sociological importance of aviation
- discuss aspects of the aerospace industry including manufacture, general aviation, commercial and instructional flying, and general aviation aircraft
- identify aviation career opportunities and the requirements for employment

Aviation Science B — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Aviation Science A
3862 1 semester ½ credit

Upon completion of Aviation Science B, the student should be able to:

- read teletype and sequence reports of winds aloft and terminal forecasts
- compute problems of speed, time, disturbance, true airspeed; and make nautical to statute conversions
- compute using wind side of computer
- explain symbols and hydrographic features of the aeronautical charts
- locate information related to a cross country (X-C) flight, using the Airman's Information Manual
- plan an X-C course and coordinate the necessary components
- file a flight plan with enroute radio communications
- complete radio license requirements
- demonstrate use of radio communications equipment and procedures
- demonstrate proper communication with ground, tower, departure, and approach controls
- demonstrate the use of very high frequency omnirange (VOR) signals, equipment, and applications for radio navigation
- demonstrate use of the automatic direction finder (ADF)
- describe primary and secondary radar
- explain use of transponder
- explain FAA Regulations, Parts 61, 67, 91, and 300
- pass written examination on above regulations

***Biology 1 — Grades 9, 10, 11, 12**
3633 1 year 1 credit

Biology 1 is an elective course which emphasizes the study of living things through laboratory experiences and investigative techniques. The course includes a wide range of content topics which are dependent upon the previous science experiences and maturity levels of the students. Attention is given to pertinent social issues and career opportunities related to the biological sciences. The instructional guide used by biology teachers, although consistent in topics and instructional objectives, provides for flexibility in approach and activities.

*Through 1978-79, this course was titled Biology.

This course can be taught in two semesters. Either semester may precede the other. Topics in both semesters include suggested activities on the historical aspects of biology, social implications of biology, and careers in biology. Topics may be taught in any order within a semester. Biology 1-A includes the topics of cytology, reproduction, genetics, evolution, and taxonomy. Biology 2-A includes microbiology, plant and animal structure and function (including a study of the human body), and ecology.

Biology 1-A — Grades 9, 10, 11, 12
3631 1 semester ½ credit

On completion of Biology 1-A, the student should be able to:

- demonstrate the ability to use methods of qualitative and quantitative observation in developing laboratory skills and techniques unique to the scientific methods of biology
- investigate general structures, functions, biochemistry, and diversity of cells
- describe various levels of organization in living systems
- investigate perpetuation of species through sexual and asexual reproduction
- apply laws of classical genetics to problems of inheritance
- apply principles of chromosomal interitance to problems of genetic differences in individuals and populations
- demonstrate some general functions of DNA (deoxyribonucleic acid) and RNA (ribonucleic acid)
- compare theories of the origin and evolution of living things
- apply methods of taxonomy to classification of major groups of organisms

Biology 1-B — Grades 9, 10, 11, 12
3632 1 semester ½ credit

Upon completion of Biology 1-B, the student should be able to:

- describe important characteristics of microorganisms which separate them from higher forms of life
- describe roles of microorganisms
- investigate general anatomy and physiology of plant systems
- investigate general anatomy and physiology of animal systems
- investigate general anatomy and physiology of human systems
- investigate the biological basis of behavior of a variety of living things
- demonstrate organization, energy flow, and development of ecosystems
- compare relationships of organisms within and among ecosystems

***Biology 2 — Grades 10, 11, 12**
3643 1 year 1 credit

Biology 2 is an elective course for students with a special interest and high motivation for an indepth study of the biological sciences. For all topics, the emphasis is on laboratory investigation. Prerequisites are the attainment of the objectives of Biology 1 and, when the student has not attained the objectives of Chemistry 1 and will not be taking it concurrently, counseling based on 1) recommendations of teachers who have taught the student and 2) performance in previously taken science courses.

Biology 2 builds on the concepts and principle material covered in Biology 1, with greater detail in content and with additional topics and laboratory investigations. An opportunity is provided for an independent research project. Although the course does not follow the Advanced Placement Curriculum, a student may elect to take the Advanced Placement Biology Examination and may qualify for college placement.

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*Through 1978-79, this course was titled Advanced Biology.

The course can be taught in two semesters. **Biology 2-A** is a prerequisite for **Biology 2-B**. Topics in **Biology 2-A** are unity of life, including microtechniques; cellular energetics; and genetics, including chromosome mapping, karotyping, transduction, and cloning. **Biology 2-B** includes land plants; vertebrate physiology and development; evolution, including speciation, isolating mechanisms, and adaptations of species; ecology, including interspecific and intraspecific competition; and behavior.

Biology 2-A — Grades 10, 11, 12
3641 1 semester ½ credit

Upon completion of **Biology 2-A**, the student should be able to:

- understand the mechanics of bonding and the composition of the important organic molecules and water
- analyze the theories about the origin of life on earth
- compare prokaryotic and enkaryotic cells
- understand cellular ultrastructures and functions of these structures
- describe current concepts on membrane structure and function
- understand the principles of enzymology
- discuss the principles of energy transformations in the cell
- compare cellular energetics of respiration, fermentation, and photosynthesis
- analyze the phases and patterns of karyokinesis
- discuss cytokinesis in plants and animals
- understand the mechanisms of cellular transcription
- perform an extensive investigation of Mendelian and post-Mendelian genetics
- compare the structure and relationship of a chromosome and a gene
- describe genetic control of replication and protein synthesis
- discuss genetic recombination and current research in genetic engineering
- discuss cloning
- understand the phylogenetic trends in plant and animal phyla

Biology 2-B — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Biology 2-A
3642 1 semester ½ credit

Upon completion of **Biology 2-B**, the student should be able to:

- understand the relationship between structure and function of organs in angiosperms
- trace the growth and development processes in angiosperms
- discuss the process of cellular differentiation including the role of the organizer in induction
- compare the functions of embryonic membranes in avian and mammalian development
- discuss the actions and interactions of organs and organ systems for each system in humans and relate how they coordinate their actions
- understand the principles of homeostasis and feedback mechanism in physiological processes of higher animals
- discuss evolutionary changes according to Lamarck, Darwin, and current theorists
- discuss evolutionary adaptations of higher animals and possible reasons for the succession to a land life
- describe how geographically isolated populations will diverge over long periods of time (speciation)
- discuss the flow of energy through ecosystems
- discuss populations and interspecific interactions within the biotic community
- understand the mechanisms of animal communication, biorhythms, territoriality, and aggression

Biology, Advanced Placement — Grades 10, 11, 12
3653 1 year 2 credits

This is a double-credit course which meets two class periods each day. The course has the same objectives and prerequisites as Biology 2, with the provision that the content, materials, and activities of Biology, Advanced Placement follow the Advanced Placement curriculum. The course is designed specifically for students who wish to take the Advanced Placement Biology Examination; and/or enroll in an honors program in college; and/or pursue a career in biology or a biology-related field. Students may not earn credit for both Biology 2 and Biology, Advanced Placement.

The course can be taught in two semesters. The topics for Biology, Advanced Placement A and Biology, Advanced Placement B are the same as for Biology 2 with the additional instructional objectives shown below. The sequence of topics within a semester is flexible. Biology, Advanced Placement A is a prerequisite for Biology, Advanced Placement B.

Biology, Advanced Placement A — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Biology 1
3651 1 semester 1 credit

Upon completion of Biology, Advanced Placement A, in addition to the objectives for Biology 2-A, the student should be able to:

- know the history of cytology from Robert Hooke through present-day hypotheses
- comprehend the oxidative-reduction reactions for photosynthesis (light and dark reactions), respiration, phosphorylation, glycolysis, citric acid cycle, and cytochrome reactions
- describe the leading theories concerning the origin of life; additional topics concerning the changes that have occurred in organisms; archeological evidences; supporting paleontological finds that support theories; and current literature updating macro and microevolution as well as biogeography and protein sequencing
- know the history of inheritence from Mendel through present-day cistron sequencing
- use of karyotyping as a method to identify genetic abnormalities

Biology, Advanced Placement B — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Biology, Advanced Placement A
3652 1 semester 1 credit

Upon completion of Biology, Advanced Placement B, the student should be able to:

- understand the relationship between structural and functional systems of gymnosperms
- trace the growth and develop processes of gymnosperms
- describe advanced tissue induction, reorientation of cellulose fibrils, and reversible differentiation
- design a behavior problem — perform observations, collect data, and formulate an analytical summary
- conduct an investigation which correlates ecological, evolutionary, and ethological biology in theory and field practice
- debate ecological trends; conservation practices; irradication measures; population growth and control; pollution factors; and human responsibliity and influence

***Chemistry 1 — Grades 10, 11, 12**
3723 1 year 1 credit

Chemistry 1 is an elective course which emphasizes a laboratory approach to problem solving as well as a body of basic knowledge. Enrollment is open, following counseling if the student has not attained the objectives of Algebra 2 and will not be taking it concurrently. The counseling is to be based on 1) recommendations of teachers who have taught the student and 2) performance in previously taken science courses.

The study of chemistry is significant for students who plan on pursuing a career in science and/or who wish to become well informed in an ever changing, increasingly technological society. Various theories and practical applications are presented in Chemistry 1 which will serve the student in future years. There are several different published approaches to the study of chemistry. These differ only in topic order and style. All contain the topics and objectives below. The instructional guide used by chemistry teachers, although consistent in topics and instructional objectives, provides for flexibility in approach and activities.

The course can be taught in two semesters. Chemistry 1-A is a prerequisite for Chemistry 1-B. Topics may be taught in any order within a semester. Chemistry 1-A topics include methods of chemists; measurement; classification and organization of matter; atomic theory; mole concept; kinetic theory and gas laws; characteristics of liquids and solids; electrical nature of matter; periodic table and quantum numbers; chemical bonds; and history of chemistry. Chemistry 2-A includes solubility; reaction rates; equilibrium; acids and bases; oxidation-reduction; compounds of carbon; radioactivity; and career choices.

Chemistry 1-A — Grades 10, 11, 12
3721 1 semester ½ credit

Upon completion of Chemistry 1-A, the student should be able to:

- describe the major developments in the history of chemistry
- define significant digits and scientific notation
- determine the formula of a compound, the percent composition and molecular weight of substances
- determine weight and volume relationships in an equation
- demonstrate chemical and physical reactions quantitatively in terms of the mole concept
- describe atomic periodicity based on elementary orbital modes of the atom
- describe elements using two quantum numbers
- describe the function of elements as the individual building blocks of matter
- relate the occurrence and properties of elements to their recurring positions on the Periodic Table
- apply generalizations in order to describe physical and chemical properties of specific elements
- describe the process of electron transfer that brings about chemical change
- explain the ability of some substances to lose electrons and others to gain them
- compare various kinds of chemical bonds according to the kinds of elements involved, the relative strength of the bonds, and the properties of the resulting substances
- solve problems involving the measurement of gases
- describe types of crystal packing
- conduct laboratory investigations using common elements and compounds studied in Chemistry 1-A

*Through 1978-79, this course was titled Chemistry.

Chemistry 1-B — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Chemistry 1-A
3722 1 semester ½ credit

Upon completion of Chemistry 1-B, the student should be able to:

- interpret various factors that affect the rate of a chemical reaction
- investigate various factors that affect the chemical and physical equilibrium of a system
- recognize the Arrhenius and Brönsted-Lowry definition of acids and bases
- investigate the general properties common to all acids or bases in water solution
- use pH to classify chemical substances
- identify the physical and chemical properties and structure of basic carbon compounds
- describe the nature of radioactivity and the stable radioactive particles
- discuss the application of atomic energy to science and society
- conduct laboratory investigations using common elements and compounds studied in Chemistry 1-B
- describe career opportunities in chemistry and chemistry-related fields

***Chemistry 2 — Grades 11, 12**
Prerequisite: Attainment of objectives of Chemistry 1 and Algebra 2
3743 1 year 1 credit

Chemistry 2 is designed for the highly motivated student who wishes to achieve additional skills to ensure greater success in the first year chemistry course at the college level. In Chemistry 2, the emphasis is on problem solving, laboratory and organizational skills, independent study habits, and self-discipline while engaged in chemical investigations. Prerequisites are attainment of objectives of Chemistry 1 and Algebra 2. Special circumstances may require instructor, counselor, and parent/guardian approval.

In Chemistry 2-A, the topics are atomic theory, bonding, phases of matter, solutions, statistical treatment of data, and laboratory methods.

In Chemistry 2-B, the topics are types of reactions and equations, equilibrium kinetics and thermodynamics, statistical treatment of data, and laboratory methods.

The sequence of topics within a semester are flexible. Chemistry 2-A is a prerequisite for Chemistry 2-B.

Chemistry 2-A — Grades 11, 12
3741 1 semester ½ credit

Upon completion of Chemistry 2-A, the student should be able to:

- relate atomic number and mass number to isotopes, mass spectroscopy, and electron energy levels
- explain quantum numbers and atomic orbitals using atomic spectra
- define metallic bonds and van der Waals forces
- predict molecular structure based upon geometry and polarity
- explain valence bond theory, hybridization of orbitals, sigma and pi bonds, and resonance
- interpret phase diagrams
- identify types of solutions and factors affecting solubility
- solve problems involving molality, normality, formality
- use Raoult's Law to determine molecular weight

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*Through 1978-79, this course was titled Advanced Chemistry.

Chemistry 2-B — Grades 11, 12
Prerequisite: Attainment of the objectives of Chemistry 2-A
3742 1 semester ½ credit

Upon completion of Chemistry 2-B, the student should be able to:

- compare Arrhenius, Brönsted-Lowry, and Lewis acid-base theory and their reactions
- discuss precipitation reactions as a qualitative analysis tool
- balance redox reactions with respect to electron transfer
- solve problems involving stoichiometric relationships
- discuss the concept of dynamic equilibrium and LeChatlier's Principle
- perform calculations involving the mass action expression and equilibrium constants
- determine the application of pH, pOH, pK, K_a, K_b, K_{sp}, K_{inst}
- investigate common ion effect, buffers, and hydrolysis in appropriate equilibrium calculations
- identify the rate-determining step in deducing reaction mechanisms
- investigate the heat of formation and reaction, heat capacity, and enthalpy
- recognize techniques of periodical research
- calculate general statistics using the rules for eliminating suspect data
- perform calculations using significant figures and scientific notation
- demonstrate the use of volumetric glassware and modern instrumentation

Chemistry, Advanced Placement — Grades 11, 12
3753 1 year 2 credits

This is a double credit course which meets two class periods each day. The course has the same objectives and prerequisites as Chemistry 2, with the provision that the content, materials, and activities of Chemistry, Advanced Placement follow the Advanced Placement curriculum. The course is designed specifically for students who wish to take the Advanced Placement Chemistry Examination; and/or enroll in an honors program in college; and/or pursue a career in a chemistry-related field. Students may earn credit for both Chemistry 2 and Chemistry, Advanced Placement.

The course can be taught in two semesters. The topics are the same as for Chemistry 2 with the additional instructional objectives shown below. The sequence of topics within a semester is flexible. Chemistry, Advanced Placement A is a prerequisite for Chemistry, Advanced Placement B.

Chemistry, Advanced Placement A — Grades 11, 12
3751 1 semester ½ credit

Upon completion of Chemistry, Advanced Placement A, in addition to the objectives for Chemistry 2-A, the student should be able to:

- perform calculations using the Rydberg constant and the wave formula
- calculate the energy levels of the Bohr atom
- investigate atomic weights using specific heat and the rule of Pettit and Dulong
- predict the structure of coordination complexes
- utilize dipole moments in determining molecular geometry
- relate the Boltzmann distribution to kinetic energy
- interpret deviations from the Ideal Gas Law and the need for the van der Waals correction factor
- interpret the changes of state in terms of critical phenomena
- discuss the effect of interionic attraction on colligative properties and solubility using Debye-Huckel theory
- categorize colloids and emulsifying agents based on particle size

Chemistry, Advanced Placement B — Grades 11, 12
Prerequisite: Attainment of the objectives of Chemistry, Advanced Placement A
3752 1 semester ½ credit

Upon completion of Chemistry, Advanced Placement B, the student should be able to:

- investigate amphoterism and the appropriate use of the concept
- demonstrate Faraday's Law and the Nernst equation and their use in suitable reactions
- relate activity coeffecients to solubility and pH
- calculate equilibrium constants and reaction order
- explain the second law of thermodynamics in terms of equilibrium
- calculate Gibbs Free Energy, entropy, and enthalpy changes to predict spontaneity of reactions
- calculate an analysis of variance and the significant difference between means of samples
- apply a qualitative analysis scheme to describe the chemistry of the ions in the scheme

Earth Science — Grades 10, 11, 12
3813 1 year 1 credit

Earth Science is an elective high school course which emphasizes the laboratory application and field study of biological, chemical, and physical principles to the study of selected topics in astronomy, meteorology, geology, oceanography, and associated sciences. Attention is given to the impact of the Space Age and the relevance of Earth Science to current environmental issues. The course can be taught in two semesters, with units and topics pertaining to astronomy and meteorology in one semester and geology and oceanography in the other. The units within a semester can be reordered or sequenced to meet the needs of students and the local school program. Either semester can precede the other.

The units for study in Earth Science A are the solar system and its exploration; the earth and its motions; and the earth's atmosphere. Earth Science B includes minerals and their origins; igneous petrology; weathering and erosion; sedimentary petrology and oceanography; structural geology and metamorphism; and historical geology.

Earth Science A — Grades 10, 11, 12
3811 1 semester ½ credit

Upon completion of Earth Science A, the student should be able to:

- utilize the outdoors for observing and gathering pertinent data
- study the relationships between matter and energy in the universe
- use methods for measuring radiant energy
- learn the characteristics of stars and star systems
- develop hypotheses regarding star evolution
- analyze theories regarding the origin of the universe
- observe members of the solar system and describe characteristics which distinguish them from other celestial objects
- compare observed celestial motions with historical descriptions and explain the causes of these motions
- use prior knowledge and certain assumptions to analyze and critique theories regarding the origin of the solar system
- observe the moon and describe factors which affect its motion, appearance in the sky, and surface features
- describe space navigation in terms of physical laws
- describe the objectives and activities of the space program

- use observations, other evidences, and physical laws to study the earth's shape, size, and magnetic field
- use maps and navigational techniques to locate points on the earth's surface
- measure and verify earth motions and relate the motions to seasonal changes and time
- study the chemical and physical characteristics of the atmosphere
- use observations and data to study the effects of air pollution on the environment and the problems of conserving the atmosphere
- learn the effects of radiant energy on the atmosphere and resulting weather phenomena
- use various instruments to collect and interpret data regarding atmospheric conditions
- use weather maps to analyze the formation of storms and associated weather and use these analyses and collected data to predict local weather conditions

Earth Science B — Grades 10, 11, 12
3812 1 semester ½ credit

Upon completion of Earth Science B, the student should be able to:

- use laboratory tests to determine chemical and physical properties of minerals
- study mineral samples, using a mineral identification key
- study the formation and origin of minerals
- recognize the economic importance of mineral ores as natural resources and the need to conserve them as part of the environment
- classify igneous, sedimentary, and metamorphic rocks according to their physical and chemical properties
- analyze igneous rocks to describe their origin
- classify different types of landforms resulting from vulcanism
- observe and interpret the effects of weathering and erosion on soil formation and conservation in the local environment
- know the effects of various factors on the action of ground water and develop an awareness of the need to conserve our water supply
- observe and analyze the effects of running water on the earth's surface
- learn the effects of wind erosion and glaciation, and critique hypotheses regarding the causes of the Ice Age
- determine physiographic provinces from different data sources
- associate physical laws and geologic activities with the formation of sedimentary deposits
- analyze the physical and chemical characteristics and origins of the ocean currents
- recognize the significance of scientific exploration and conservation of ocean life
- use mathematical models to verify characteristics and origin of waves
- describe the interior structure of the earth in terms of physical characteristics and chemical composition
- use topographic and other evidences to draw geologic maps and cross sections
- know types of crustal movement and hypotheses regarding the formation of the continents
- interpret seismic waves to determine earthquake locations and criticize theories regarding the earth's interior
- learn conditions related to the formation of metamorphic rocks
- express geologic time in meaningful terms of radioactive data and fossil techniques
- develop hypotheses regarding the origin of the earth's lithosphere, hydrosphere, atmosphere, and the origin of life
- interpret geologic maps and cross sections to determine the origin of geologic formation

Environmental Science — Grades 10, 11, 12
3663 1 year 1 credit

Environmental Science A — Grades 10, 11, 12
3661 1 semester ½ credit

Environmental Science B — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Environmental Science A
3662 1 semester ½ credit

Environmental Science deals with interactions between people and their environment. Emphasis throughout is on the physical and biological processs. The systematic study of global realms — atmosphere, hydrosphere, lithosphere, and biosphere — provides students with an understanding of natural processes. Environmental problems are viewed in the context of these natural events. The course can be taught in two semesters.

Environmental Science A is an overview of the nature of ecosystems; energy flow; interrelationships of biology, geology, and chemical cycles; population studies; organization and dynamics of ecological communities; environmental pollution. During Environmental Science B, students have an opportunity to pursue optional investigations and experiments.

Upon completion of the course, the student should be able to:

- demonstrate knowledge of natural laws and the relationship of these laws to human activities
- identify the main sequences and the importance of natural cycles (biological, geological, and chemical)
- describe the biotic and abiotic interrelationships that exist in an ecological community
- discuss and describe the hazards of overpopulation
- describe specific ecosystems in terms of changing biotic and abiotic factors
- define and/or identify significant terms associated with the topics and concepts included in the course content
- interpret and draw valid conclusions from graphs, tabular data, taxonomic keys

***Horticultural Science — Grades 10, 11, 12**
3673 1 year 1 credit

Horticultural Science A — Grades 10, 11, 12
3671 1 semester ½ credit

Horticultural Science B — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Horticultural Science A
3672 1 semester ½ credit

Horticultural Science is designed for those students interested in mastering fundamental techniques in the care and culture of plant life in the home, business, and community environments. Major attention is given to plant propagation; taxonomy; genetics, and experimentation appropriate to the facilities available. Students are encouraged to pursue individual areas of interest. Opportunities are provided for participation activities that involve application of skills and knowledge acquired. The course can be taught in two semesters.

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*Through 1978-79, this course was titled Horticulture.

Horticultural Science A is an overview of topics such as plant classification and identification; plant anatomy and physiology; soils and their preparation; control of disease, weeds, and pests; and plant propagation. Horticultural Science A is a prerequisite for Horticultural Science B.

During Horticultural Science B, students select topics from those presented in the overview for indepth study. Attention is given to experimental research, landscaping, and greenhouse management. Opportunity for experimental activities is provided.

Upon completion of Horticulture, the student should be able to:

- demonstrate the techniques employed in the propagation of plants
- use taxonomic keys to identify plants
- name and identify the major anatomic structures of higher plants
- describe soil formation, composition, and types
- demonstrate techniques for adjustment of soils for optimum growth conditions
- compare and contrast chemical and biological control of disease, weeds, and pests
- describe vocational and professional opportunities in the field of horticulture
- demonstrate a knowledge of techniques for proper greenhouse management
- demonstrate various plant display techniques such as bonsai, dish gardens, terrariums, hanging arrangements, floral arrangements
- identify and apply the fundamental principles of landscape design

***Physical Science 1 — Grades 10, 11, 12**
3943 1 year 1 credit

Physical Science 1 is an elective survey course which covers selected chemistry and physics topics for students who probably will not elect either of those courses. There is an emphasis on the practical and functional applications of science including laboratory investigations. The course is open, following counseling if the student has not attained the objectives of Algebra 1 and will not be taking it concurrently. The counseling is to be based on 1) recommendations of teachers who have taught the student, and 2) performance in previously taken science courses. The course can be taught in two semesters. Physical Science 1-A includes topics of matter and energy and applications of chemistry. Physical Science 1-B includes force and motion; wave motion and energy; and electromagnetic energy. Either semester can precede the other.

Physical Science 1-A — Grades 10, 11, 12
3941 1 semester ½ credit

Upon completion of Physical Science 1-A, the student should be able to:

- apply measurement skills to perform simple experimentation
- describe the properties of sub-atomic particles and the concept of atomic structure
- write chemical equations
- investigate common classes of chemical substances
- describe the general nature, properties, and uses of radioactivity
- describe fossil fuels
- know basic concepts of organic chemistry

*Through 1978-79, this course was titled Physical Science.

Physical Science 1-B — Grades 10, 11, 12

3942 1 semester ½ credit

Upon completion of Physical Science 1-B, the student should be able to:

- investigate concepts of torque, center of gravity, velocity, and acceleration
- describe the relationship of mass and weight
- investigate concepts of work, power, potential and kinetic energy, and efficiency
- investigate wave motion, sound, light, and color
- describe electrostatics, including static and current electricity
- investigate the relationship of electric current magnetism
- describe the application of the electromagnetic nature of matter to electronics

***Physical Science 2 — Grades 11, 12**

Prerequisites: See below.

3953 1 year 1 credit

This is an elective laboratory course for students planning careers in the physical sciences and or engineering. Prerequisites are attainment of the objectives of Physics 1 or Physical Science 1 and, where the student has not attained the objectives of Trigonometry and will not be taking it concurrently, counseling based on 1) recommendations of teachers who have taught the student and 2) performance in previously taken science courses.

The course can be taught in two semesters. Physical Science 2-A includes topics of applied mathematics and basic concepts in heat and thermodynamics. Physical Science 2-B includes applied science and engineering research and concepts of classical and modern physics. Physical Science 2-A is a prerequisite for Physical Science 2-B.

Physical Science 2-A — Grades 11, 12

3951 1 semester ½ credit

Upon completion of Physical Science 2-A, the student should be able to:

- collect data, order data, and recognize when an elementary statistical analysis would be useful
- compute and interpret mean, mode, median, variance, standard deviation; and interpret a correlation coefficient
- analyze raw experimental data by testing to determine whether it may be approximated by a linear, exponential, power, or polynomial rule (function)
- use least squares methods to identify the constants in linear, power, exponential, and polynomial function
- apply rules to determine whether or not the area bounded by a curve has physical significance
- select and use approximation techniques to find the area bounded by a curve when a rule of correspondence either has not been determined or cannot easily be found
- set up, solve, and interpret one kind of simple Random Walk problem
- describe the empirical nature of thermodynamics
- state and interpret the first and second laws of thermodynamics
- discuss free energy and work content
- describe the conversion of heat into work
- describe the application of thermodynamics

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*Through 1978-79, this course was titled Advanced Physical Science.

Physical Science 2-B — Grades 11, 12
Prerequisite: Attainment of the objectives of Physical Science 2-A
3592 1 semester ½ credit

Upon completion of Physical Science 2-B, the student should be able to:

- identify the kinds of problems that may be analyzed with mathematical-statistical modeling
- describe the various ways in which the word "systems" is used in science, industry, and government
- state a single problem in several different ways, and describe the implications of each statement
- recognize certain unwritten assumptions associated with the way problems are stated
- present an experimental design gathering strategy for a mini-project

***Physics 1 — Grades 10, 11, 12**
Prerequisite: Attainment of objectives of Algebra 2
3833 1 year 1 credit

Physics 1 is an elective course for students who wish to investigate physical laws and theories, relationships of physical phenomena, and the impact of human life on the physical environment. A prerequisite is attainment of the objectives of Algebra 2. The course can be taught in two semesters. Physics 1-A is a prerequisite for Physics 1-B. Physics 1-A includes the topics vector mathematics, kinematics, and dynamics. Physics 1-B includes heat, electricity, optics, and modern physics.

Physics 1-A — Grades 10, 11, 12
3831 1 semester ½ credit

Upon completion of Physics 1-A, the student should be able to:

- perform graphic additions of vectors
- demonstrate the resolution of vectors into components
- demonstrate the addition of vectors by components
- solve problems involving forces and equilibriums
- apply equations describing linear motion
- describe trajectories
- analyze uniform circular motion
- describe models of the solar system and the application of Kepler's Laws
- apply Newton's Laws of Motion to problems involving unbalanced forces
- derive momentum conservation from Newton's Laws
- apply momentum conservation to problems of interaction
- apply conservation of kinetic energy and momentum to collision problems
- solve problems involving work, potential energy, and kinetic energy
- apply the Universal Law of Gravitation

*Through 1978-79, this course was titled Physics.

Physics 1-B — Grades 10, 11, 12
Prerequisite: Attainment of the objectives of Physics 1-A
3832 1 semester ½ credit

Upon completion of Physics 1-B, the student should be able to:

- solve problems involving Ideal Gas Laws
- apply the kinetic molecular theory to relationships between kinetic energy and temperature
- solve general problems of thermodynamics
- describe phenomena related to electrostatic charge generation and induction
- apply Coulomb's Law and electrostatic potential
- solve problems of magnetic forces on and due to moving charges
- define electromagnetic waves and energy transfer
- apply laws of geometric optics, including intensity, reflection, refraction, and thin lens optics
- analyze the propagation of waves, including reflection, refraction, diffraction, and interference
- analyze the hydrogen spectrum
- apply the uncertainty principle to the Bohr model of the atom
- describe photoelectric effect

***Physics 2 — Grades 11, 12**
Prerequisites: See below.
3843 1 year 1 credit

Physics 2 is a second course for students who have shown special aptitude and interest in the physical sciences. The content and activities are college level and prepare interested students for the Advanced Placement examination in physics. Prerequisites are attainment of the objectives of Physics 1 and, when the student has not attained the objectives of Calculus and will not be taking it concurrently, counseling based on 1) recomendations of teachers who have taught the student and 2) performance in previously taken science courses. The course can be taught in two semesters. Physics 2-A is a prerequisite for Physics 2-B.

During Physics 2-A, students examine the field of mechanics including vectors; kinematics; particle dynamics; work; momentum; collisions; rigid body motion; gravitation and planetary motion; and oscillations.

During Physics 2-B, emphasis is placed on electricity and magnetism including electric charge, Coulomb's Law, and electric field; Gauss' Law; electrical potential; capacitance and dielectrics; energy storage in capacitors; electric currents (circuits, energy, and power); magnetic field (forces on moving charges and on current-carrying wires); Ampere's Law (integral form, applications, and the Biot-Savart Law); and electromagnetic induction (Faraday's Law in integral form).

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*Through 1978-79, this course was titled Advanced Physics.

Physics 2-A — Grades 11, 12

3841	1 semester	½ credit

Upon completion of Physics 2-A, the student should be able to:

- resolve vectors for velocity, acceleration, and force
- solve equilibrium problems using vectors
- describe (by equations) simple and complex motions including rectilinear motion, motion in a place, and motion in a gravitational field
- use the three laws of thermodynamics to explain the basic processes involved in heat flow

Physics 2-B — Grades 11, 12

Prerequisite: Attainment of the objectives of Physics 2-A

3842	1 semester	½ credit

Upon completion of Physics 2-B, the student should be able to:

- define and use the basic quantities for electricity — charge, field, electric potential, power, current, and capacitance
- solve problems using Gauss' Law in integral form; Coulomb's Law; capacitance; Ampere's Law in integral form; Biot-Savart Law; and Faraday's Law in integral form
- determine the forces exerted on or by a charge moving in a field
- solve a minimum of five problems on each of the topics listed in the course outline

Internship — Science — Grades 10, 11, 12

3511	Semester A	½ credit
3512	Semester B	½ credit
3513	1 year	1 credit
3521	Semester A	1 credit
3522	Semester B	1 credit
3523	1 year	2 credits

The Science Internship is an open, elective course for students interested in a science laboratory or science field research experience out of school. Students are placed, according to their interest and the availability of space, in private or government research agencies such as the National Institutes of Health and the National Bureau of Standards. The description and requirements for participation in the internship program are in the *Administrative Handbook on Student Internships*, Department of Instructional Planning and Development (formerly the Department of Curriculum and Instruction), 1977.

MCPS INSTRUCTIONAL GUIDES AND RELATED REFERENCES FOR SCIENCE, GRADES 9-12

MCPS Instructional Guides

Instructional Guide for Laboratory Science, Field Test Edition, Fall 1977.

Test Item Bank, Laboratory Science, Revised Edition, Fall 1977.

Instructional Guide for Earth Science, Field Test Edition, Fall 1977.

Test Item Bank, Earth Science, Revised Edition, Fall 1977.

Related References

MCPS Administrative Handbook on Student Internships, 1977.

Environmental Education: A Maryland Approach, Maryland State Department of Education, 1974.

Maryland School Science Facility Guidelines, 1977, Maryland State Department of Education and Maryland Interagency Committee on School Construction.

Outdoor Education Program Handbook, 1977-78.

MCPS Safety Handbook, July 1971.

Summary of Contracts (issued annually by the Division of Procurement)
- Bid, General and Biological Chemicals
- Bid, Microscopes
- Bid, Secondary School Science Supplies and Equipment
- Quote, Purchasing of Live, Preserved, and Miscellaneous Biological Materials

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